

**U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM**

SCIENTIFIC NAME: *Calidris canutus rufa*

COMMON NAME: Red Knot (subspecies *rufa*)

LEAD REGION: Region 5

INFORMATION CURRENT AS OF: April 25, 2007

STATUS/ACTION

Species assessment - determined we do not have sufficient information on file to support a proposal to list the species and, therefore, it was not elevated to Candidate status

☒ New candidate

☐ Continuing candidate

☐ Non-petitioned

☒ Petitioned - Date petition received: August 9, 2004; August 5, 2005

☐ 90-day positive - FR date:

☐ 12-month warranted but precluded - FR date:

☐ Did the petition request a reclassification of a listed species?

FOR PETITIONED CANDIDATE SPECIES:

a. Is listing warranted (if yes, see summary of threats below)? Yes

b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? Yes

c. If the answer to a. and b. is "yes," provide an explanation of why the action is precluded. We find that the immediate issuance of a proposed rule and timely promulgation of a final rule for this species has been, for the preceding 12 months, and continues to be, precluded by higher priority listing actions (including candidate species with lower Listing Priority Numbers [LPN]). During the past 12 months, most of our national listing budget has been consumed by work on various listing actions to comply with court orders and court-approved settlement agreements, meeting statutory deadlines for petition findings or listing determinations, emergency listing evaluations and determinations, and essential litigation-related, administrative, and program management tasks. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures. For information on listing actions taken over the past 12 months, see the discussion of "Progress on Revising the Lists," in the current Candidate Notice of Review which can be viewed on our Internet website (<http://www.fws.gov/endangered/candidates/>).

___ Listing priority change
 Former LP: ___
 New LP: ___

Date when the species first became a Candidate (as currently defined): August 23, 2006

- ___ Candidate removal: Former LPN: ___
- ___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
 - ___ U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.
 - ___ F – Range is no longer a U.S. territory.
 - ___ I – Insufficient information exists on biological vulnerability and threats to support listing.
 - ___ M – Taxon mistakenly included in past notice of review.
 - ___ N – Taxon does not meet the Act's definition of "species."
 - ___ X – Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Birds: Scolopacidae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Found in United States during migration and/or winter in New Jersey, Delaware, Florida, Georgia, South Carolina, North Carolina, Virginia, Maryland, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine. Historical breeding area is Canadian Arctic. Historical overwintering primarily in southern South America in Chile, Argentina and Brazil. During migration and winter historically found from mid-Atlantic United States south to southern South America (Harrington 1996; 2001; Niles *et al.* 2005).

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE: Found in United States during migration and/or winter in New Jersey, Delaware, Florida, Georgia, South Carolina, North Carolina, Virginia, Maryland, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine. Breeds in central Canadian Arctic. Found overwintering primarily in southern South America in Chile, Argentina and Brazil. During migration and winter found from mid-Atlantic United States south to southern South America (Harrington 1996; 2001; Niles *et al.* 2005).

LAND OWNERSHIP: In the United States approximately 25 percent of sites are federally owned, 40 percent are State-owned; 10 percent are municipal or County-owned; and 25 percent are privately owned. Land ownership of the principal wintering areas in South America is approximately 75 percent federal or other public land and 25 percent privately owned. Of the known arctic breeding sites identified in Canada, approximately 50 percent are on federal lands, 35 percent are privately owned, and ownership of remaining areas is unknown (Niles *et al.* 2005).

No ownership information is available for migration and secondary wintering areas in Mexico, the Caribbean, Central America, and northern South America.

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BIOLOGICAL INFORMATION

Species Description

The red knot (*Calidris canutus*) is a medium-sized shorebird about 9 to 11 inches (in) (23 to 28 centimeters) in length with a proportionately small head, small eyes, short neck, short tibia, and stout tarsus. The black bill tapers steadily from a relatively thick base to a relatively fine tip; bill length is not much longer than head length. Legs are typically dark gray to black, but sometimes greenish in juveniles or older birds in non-breeding plumage (Harrington 2001). During the breeding season, the plumage of the red knot is distinctive and easily recognizable. The face, breast, and upper belly are a rich rufous-red, while the lower belly and under tail-covert region are light-colored with dark flecks. Upperparts are dark brown with white and rufous feather edges; outer primary feathers are dark brown to black (Davis 1983; Harrington 2001). Females are similar to males, though rufous colors are typically less intense, with more buff or light gray on dorsal parts (Niles *et al.* 2005). Non-breeding plumage is dusky gray above and whitish below. Juveniles resemble non-breeding adults, but the feathers of the scapulars and wing coverts are edged with white and have narrow, dark subterminal bands, giving the upperparts a scalloped appearance (Davis 1983). Body mass varies seasonally, with lowest mean mass during early winter (125 grams (gm)) and highest mean values during spring (205 gm) and fall (172 gm) migration (Harrington 2001).

C. c. rufa is the palest subspecies. The chin, throat, breast, flanks, and belly are characteristically brick red or salmon red, sometimes with a few scattered light feathers mixed in. The undertail is white, often including scattered brick-red or salmon-red feathers, marked with dark, terminal chevrons laterally. The crown and nape are streaked with black and gray and/or salmon; prominent superciliary stripe is brick red or salmon red, auricular region and lores are colored as in the crown, but with finer streaks. Back-feathers and scapulars have dark brown-black centers edged with faded salmon. Scapulars and tertials are unevenly colored, with broad, dark, irregular-shaped centers, widely edged in notched patterns to variable degrees, some with faded salmon and others with bright salmon-red color. The lower back and upper tail-coverts are barred black and white, with scattered rufous. Primary feathers are dark brown to black, secondaries and remiges are gray. Younger males tend to be less brightly colored dorsally and have greater numbers of light feathers scattered among ventral feathering. The underwing is duller than in other *Calidris* subspecies (Tomkovich 1992; Harrington 2001).

Taxonomy

The red knot is classified in the Class Aves, Order Charadriiformes, Suborder Charadrii, Family Scolopacidae, Subfamily Scolopacinae (American Ornithologists Union (AOU) 2005). The AOU recognizes six subspecies of *Calidris canutus*, each with distinctive morphological traits (*i.e.*, body size and plumage characteristics), migration routes, and annual cycles. Six separate breeding areas are known to host different populations, all of which are now recognized as subspecies (Piersma and Davidson 1992; Tomkovich 1992; Piersma and Baker 2000; Tomkovich 2001; Beuhler and Baker 2005).

Three of the six subspecies occur in North America: *C. c. islandica*, *C. c. roselaari*, and *C. c. rufa*. The subspecies *C. c. islandica* breeds in the northeastern high Canadian Arctic and Greenland, migrates through Iceland, and winters in western Europe. Subspecies *C. c. roselaari* is thought to breed in northwest Alaska and Wrangel Island, Russia and winters in the southeast United States, Texas coast, west coasts of North, Central, and South America and possibly northeastern South America. *C. c. rufa* breeds in the central Canadian Arctic and migrates primarily along the Atlantic coast of North America (Piersma and Davidson 1992; Harrington 2001; U.S. Fish and Wildlife Service 2003; Niles *et al.* 2005). Most *C. c. rufa* individuals winter along the coasts of South America, with the largest number found along the Chilean and Argentine shorelines of Tierra del Fuego (Harrington 2001; U.S. Fish and Wildlife Service 2003). Although some overlap of *C. c. rufa* and *C. c. roselaari* occurs in the southeastern United States during the non-breeding season and some *C. c. roselaari* may migrate through the Delaware Bay (Harrington 2001; U.S. Fish and Wildlife Service 2003; Beuhler and Baker 2005), *C. c. rufa* and *C. c. roselaari* are believed to occupy separate breeding areas (Piersma and Davidson 1992; Harrington 2001; U.S. Fish and Wildlife Service 2003; Niles *et al.* 2005).

Beuhler and Baker (2005) examined genetic variation in red knot populations. These analyses found patterns of genetic distinctiveness that complement the subdivision of red knots into the six aforementioned subspecies.

Pursuant to the definitions in Section 3 of the Endangered Species Act (ESA), "the term species includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." Based on the information described above, the red knot subspecies *rufa* is a valid taxon which qualifies as a listable entity under the ESA. For the purpose of this form, further references to the red knot pertain to subspecies *C. c. rufa*.

Habitat/Life History

Each year red knots make one of the longest distance migrations known in the animal kingdom, traveling approximately 30,000 kilometers (km) annually between wintering grounds in southern South America and breeding areas within the Canadian Arctic. Although a small population is believed to overwinter in northern Brazil, most red knots winter in southern South America along the coast of Patagonia, from approximately San Antonio Oeste, Argentina, southward to the eastern coast of Tierra del Fuego in Chile and Argentina (Harrington 2001; Baker *et al.* 2004; Morrison *et al.* 2004). In austral South American wintering areas, red knots are found

principally in intertidal marine habitats, especially near coastal inlets, estuaries, and bays, or along *restinga* formations (an intertidal shelf of densely-packed dirt blown by strong, offshore winds) (Harrington 2001).

During migration, red knots undertake long flights that may span thousands of kilometers without stopping. At some stages of migration, very high proportions of entire populations may use a single migration staging site to prepare for long flights. Migrating red knots are principally found in marine and estuarine habitats (Harrington 2001). During the spring migration, red knots stop over for a period of approximately two to three weeks along the Atlantic coast of the United States to rebuild energy reserves needed to complete the journey to the Arctic and arrive on the breeding grounds in good condition (Harrington 1996; Baker *et al.* 2003). Historically, the Delaware Bay region of Delaware and New Jersey has supported the largest known spring migration concentration of red knots and is the last major stopover area used by red knots migrating to Arctic breeding areas (Harrington 1996). Some historical records of flocks of up to 12,000 red knots have been reported along the southeastern Atlantic seaboard north to Virginia; however, observations compiled by Harrington (1996) throughout the 1980s indicate that these flights were the exception rather than the rule and that when knots were observed at areas outside of the Delaware Bay it was never for more than a brief feeding and rest stop. Approximately 90 percent of the entire population of *C. c. rufa* can be present in the Delaware Bay in a single day (Cornell Lab of Ornithology 2005). Peak counts of approximately 95,000 red knots were recorded during Bay-wide aerial surveys conducted in 1982 and 1989. Since 2003, peak counts within Delaware Bay have been substantially lower, with counts of less than 17,000 red knots recorded in the last 4 years (Niles *et al.* 2005; Clark 2006)).

In the southeastern and mid-Atlantic United States, red knots forage along sandy beaches, tidal mudflats, salt marshes, peat banks. In Florida, the birds also use mangrove and brackish lagoons. Within the Delaware Bay, red knots are found primarily on sandy beaches that front the extensive coastal marshes of the bay (Niles *et al.* 2005).

In wintering and migration habitats, red knots commonly forage on bivalves, gastropods, and crustaceans (Harrington 2001). An exception occurs each May when the majority of red knots departing South America arrive within the Delaware Bay of Delaware and New Jersey to feed on eggs of horseshoe crabs (*Limulus polyphemus*) (Wander and Dunne 1982; Harrington 1996; Harrington 2001; Niles *et al.* 2005). Piersma *et al.* (1993) suggest this divergence from other foods preferred by the red knot may be due to the bird's reduced ability to digest hard-shelled prey items as a result of physiological changes in the bird's digestive system following the sustained fasting that occurs during the flight from South to North America.

Red knots and other shorebirds that are long distance migrants must take advantage of seasonally abundant food resources at intermediate stopovers, such as the horseshoe crab eggs in Delaware Bay, to build up fat reserves for the next long distance non-stop flight (Clark *et al.* 1993). The timing of the arrival of red knots and other migratory shorebirds within the Delaware Bay typically coincides with the annual peak of the horseshoe crab spawning period (Clark *et al.* 1993; Harrington 1996; Harrington 2001; Niles *et al.* 2005).

Harrington (1996) stated that no single stopover area is more important for the red knot than the Delaware Bay because the nutritive yield of the Bay is so high. Although a single horseshoe crab egg contains an insignificant amount of energy, Harrington (1996) found that eggs "cover the beach in such astronomical profusion that the bird can eat enough in a mere two weeks to double its weight" and estimated that an individual red knot would consume almost 135,000 eggs during the Delaware Bay stopover. In a more recent study Haramis *et al.* (In press 2007); Andres pers. comm., 2007) estimated that individual red knots had a daily need of 24,000 horseshoe crab eggs. This approximate doubling of mass, from arrival at 90 to 120 gm to departure at 180 to 220 gm, is achieved annually if conditions are favorable (Baker *et al.* 2001; Baker *et al.* 2004). Individual red knots can store fat and protein at two to three times the annual average rate when horseshoe crab eggs are superabundant. Consequently, even late-arriving migrants should be able to reach these departure masses during their short stay. Research results indicate this weight gain is crucial to sustain the birds on their nonstop flight from the Delaware Bay, and for survival and successful reproduction on arctic breeding grounds (Baker *et al.* 2004) (see discussion in the Population Estimate/Status section).

In addition to the large flocks of red knots found in the Delaware Bay, red knots are found in lesser numbers elsewhere along the Atlantic Coast during the spring migration, which may be related to these other areas having lesser numbers of breeding horseshoe crabs (Niles *et al.* 2005).

Unknown numbers of non-breeding red knots remain south of breeding grounds during the breeding season. Records of non-breeding knots, usually individuals or small groups, have been reported during the breeding season in Brazil, the Caribbean, and along the Atlantic coast of the United States (Harrington 2001; Niles *et al.* 2005).

On Arctic breeding areas, red knots generally nest in dry, slightly elevated tundra locations, often on windswept slopes with little vegetation. Breeding areas are located inland, but close to arctic coasts. Nests may be scraped into patches of mountain avens (*Dryas octopetala*) or in low spreading vegetation on hummocky ground containing lichens, leaves, and moss. On Southampton Island, nests were located in exposed areas of glacial/shattered rocks and mudboils and most were located in proximity to suitable wetland foraging areas (Harrington 2001; Niles *et al.* 2005).

On the breeding grounds, the red knot's diet consists mostly of terrestrial invertebrates, though early in the season, before insects and other macroinvertebrates are active and accessible, red knots will eat grass shoots, seeds, and other vegetable matter (Harrington 2001).

The oldest red knot recorded world-wide was estimated to be 25 years old when recaptured; the oldest recorded red knot of the *rufa* subspecies was 16 years old when recaptured. Although these records indicate that the potential lifespan of a red knot is considerable, the average life span is much less. Annual adult survival in a stable population has been estimated at about 80 percent, and survival of juveniles in the wild is about 40 percent. Therefore, very few red knots live for more than about seven years (Niles *et al.* 2005).

The breeding chronology of *C. c. rufa* is poorly known. Flocks sometimes arrive at breeding latitudes before snow-free ground is available in breeding habitats. Upon arrival or as soon as favorable conditions exist, males and females occupy breeding habitat and territorial displays begin. Pair bonds form soon after and remain intact until shortly after the eggs hatch. Red knots lay only one clutch per season, and, as far as is known, do not lay a replacement clutch if the first is lost. The usual clutch size is 4 eggs, though 3-egg clutches have been recorded. No information is available regarding hatching success or chick survival rates. Young are precocial, leaving the nest within 24 hours of hatching and foraging for themselves. Although there is conflicting information, typically the female departs soon after the chicks hatch and only the male parent tends the brood until the chicks fledge (Harrington 2001; Niles *et al.* 2005). Adults migrate before juveniles (Harrington 2001).

Migrating red knots are principally found in marine and estuarine habitats (Harrington 2001). Major staging areas for red knots during the fall migration in Canada are along sandy beaches and tidal mudflats in James Bay and tidal mudflats and salt marshes in the northern Bay of Fundy. During the fall migration with the United States, red knots are found along sandy beaches, tidal mudflats and salt marshes (Niles *et al.* 2005).

Historical and Current Range/Distribution

The range of *C. c. rufa* during migration extends along the Atlantic and Gulf of Mexico coasts of North, Central, and South America, from the Canadian arctic to the southernmost extent of South America. With the exception of a few key wintering areas in South America and the spring migratory stopover site in Delaware Bay, little comparative information is available regarding the historical versus current distribution of the subspecies throughout its range.

Red knot breeding occurs within the central Canadian high arctic and has been recorded from Victoria Island southeastward to Southhampton Island, the Coats and Mansel Islands in northern Hudson Bay, and the east coast of Canada and islands within Foxe Basin. Details of historic or current distribution of red knots within the breeding range are poorly known. Little historic or current information is available for the extensive areas between Southhampton Island / Foxe Basin and southern Victoria Island (Morrison and Harrington 1992). In the late 1990s and early 2000s, additional information on breeding areas was obtained when 265 red knots were fitted with radio transmitters as the birds passed through the Delaware Bay on their way to breeding areas. During subsequent aerial searches of the known and potential breeding range, a total of 20 red knots were relocated, documenting additional breeding areas within Canada's King William Island, Boothia Peninsula, coast of Committee Bay, Melville Peninsula, southern coast of Baffin Island, and Prince Charles Island, and confirming continued breeding at Southhampton, Coats, and Mansel Islands (Niles *et al.* 2005). The eastern and western extent of the breeding range remains unclear.

Southward migration from arctic breeding areas begins in mid-July (Harrington 2001). The northernmost staging areas are along the west coasts of James Bay and Hudson Bay in Canada. In the Canadian Maritime Provinces, adult red knot numbers peak in late July to early August

with maximum numbers of juveniles appearing in late August to mid-September. On the northeastern United States coast, southward migrating red knots are distributed from Cape Cod Bay and the Chesapeake Bay with adults moving through beginning in late July, peaking in mid-August, and departing by September. In the mid to late 1970s, 60 to 90 percent of southerly migrating red knots were observed in Massachusetts and New Jersey; the relative importance of sites within these States varied from year-to-year. Migrant juveniles begin to appear along the Atlantic coastal United States in mid-August, occurring in much lower numbers and scattered over a much wider area than adults (Morrison and Harrington 1992). Numbers of red knot adults and juveniles are generally decreasing in the northeastern United States by mid-August while increasing in the mid-Atlantic States, and moving to the southeastern and Gulf coast States throughout September and October (Morrison and Harrington 1992; Harrington 2001).

After departing the United States, most red knots make landfall along the northern coast of South America, moving south along the coasts of Guyana, Suriname, and French Guiana, but not building up in appreciable numbers (Spaans 1978; Harrington 2006). Although a small population of red knots is believed to overwinter in northern Brazil, historically, the largest wintering concentrations have been found in South America along the coast of Patagonia, from approximately San Antonio Oeste, Argentina southward to the eastern coast of Tierra del Fuego in Chile and Argentina (Harrington 2001; Baker *et al.* 2004; Morrison *et al.* 2004). The birds are present in the South America wintering areas from November through February (Morrison and Harrington 1992).

Range and distribution during the fall and spring migration and winter in Mexico and Central America is not well known (Harrington 2006). The red knot is considered a rare or vagrant visitor to the Caribbean islands with the exception of Barbados, where it occurs regularly. Generally rare in the West Indies in September and October during the southbound migration, red knots occur there even less frequently while migrating northward in March and April (Raffaele *et al.* 1998).

During the spring migration, red knots begin moving northward along the Atlantic coast of South America in late February or March. Migration continues along the Argentine coast to Uruguay, Brazil, and northern South America. The northward migration is very rapid, with only brief stopovers of up to a week in northern South America. Red knots pass along the Atlantic coast of the United States from the middle to the end of May, with large flocks observed in some years along the coasts of Georgia, North Carolina, and Virginia. The largest concentrations by far occur in the Delaware Bay stopover area of Delaware and New Jersey. The birds depart the Delaware Bay in a mass exodus occurring during the last few days of May or first few days of June (Morrison and Harrington 1992; Harrington 2001; Baker *et al.* 2001; Niles *et al.* 2005). The northward migration route from the Delaware Bay bears inland with large numbers of knots observed in James Bay, Canada, on the day following a mass departure from the Delaware Bay. In some years, large concentrations of red knots have been observed at locations around Lake Ontario; these likely represent weather-induced stops. Knots pass rapidly through southern James Bay in spring, stopping only briefly (less than one day) to feed in coastal marshes before resuming their flight to the breeding grounds (Morrison and Harrington 1992).

In Florida, the ranges of *C. c. rufa* and *C. c. roselaari* are believed to overlap somewhat during migration and winter (Morrison and Harrington, 1992; Harrington 2001; U.S. Fish and Wildlife Service 2003; Buehler and Baker 2005; Niles *et al.* 2005). Red knots migrating along the Pacific Coast and through the interior of North America are generally considered to be *C. c. roselaari* (Harrington 2001; U.S. Fish and Wildlife Service 2003; Niles *et al.* 2005).

Population Estimates/Status

Assessing the population size of a wide-ranging migratory species such as the red knot is difficult. Counts on the expansive Arctic breeding areas are not feasible. Morrison *et al.* (2001) compiled published and unpublished counts of shorebirds by season and region to generate a coarse flyway population estimate for North American breeding shorebirds. Populations were determined by summing the maximum counts at various sites within a region. Using this method the *C. c. rufa* population was estimated at approximated 170,000 birds for the period of the late 1980s to early 1990s. However, the authors included the central flyway population of approximately 20,000 red knots as *C. c. rufa* (Morrison *et al.* 2001). While the origins of the central flyway red knots are uncertain, these birds are generally thought to be *C. c. roselaari* (Harrington 2001; U.S. Fish and Wildlife Service 2003; Niles *et al.* 2005). Morrison *et al.* (2001) estimated the eastern North American flyway population of *C. c. rufa* for the period of the late 1980s to early 1990s at approximately 150,000 birds, and noted that based on information through 1999, the population could be substantially lower.

Counts of wintering areas are particularly useful in estimating red knot populations and trends as the birds generally remain within a given wintering area for a longer period of time compared to the areas used in migration. This eliminates errors associated with turnover or double-counting that can occur during migration counts.

The population of red knots wintering in southern South America during the late 1980s was estimated to be in the range of 100,000 to 150,000 birds. These estimates were derived from aerial survey data and resightings of banded birds (Morrison and Harrington 1992). Currently, the most reliable information available to monitor population trends is the raw data estimates from winter aerial survey counts. Recent surveys for the red knot within known wintering areas on the coasts of Patagonia and Tierra del Fuego, where the largest wintering concentrations of red knots occur, show a substantial decline in the number of wintering birds observed. Total red knots observed in these wintering areas in 2003 were estimated at only 30,000 birds as compared to an estimated 67,500 birds observed in the mid-1980s (Morrison *et al.* 2004). In the mid-1980s wintering red knots could be found along 1,600 km of the Atlantic coast of South America from Tierra del Fuego to Rio Colorado in northern Patagonia. Surveys of a comparable area in 2003 and 2004 showed that knots have nearly disappeared from previously-used wintering sites outside of Tierra del Fuego on the Patagonian coast of Argentina; numbers counted fell from over 14,300 birds in the 1985 survey to only 560 in 2003 and 790 in 2004. In 2005 and 2006, additional aerial surveys were conducted of Bahia Lomas and other portions of Tierra del Fuego and southern Patagonia that comprise the principal red knot wintering areas in Chile and Argentina. Counts of red knots within these principal areas were 17,653 birds in 2005 and

17,211 in 2006, much lower in comparison to other years for which red knot aerial count data of the same area are available: 53,232 birds in 1985; 51,255 in 2000; 27,242 in 2002; 29,915 in 2003; and 30,778 in 2004 (Niles *et al.* 2005; Ross 2006). The Canadian Wildlife Service conducted aerial surveys in Chile and Argentina in February 2007. A total of 17,360 red knots were observed on the principal wintering areas. Although a somewhat different geographic distribution of birds was noted as compared to the past several years, the total number of birds found was similar to 2006 wintering numbers (Ross pers. comm., 2007).

These principal wintering areas supported approximately 78 to 98 percent of the red knots observed during winter aerial surveys in southern South America in those years where additional portions of the Patagonian coast were surveyed. As noted above, these areas in southern South America are not the only locations used by wintering red knots, so the survey results are best interpreted as indications of population trends rather than estimates of the total population of red knots. In an updated estimate of North American shorebird populations, Morrison *et al.* (2006) estimated the red knot population wintering in southern South America to be as low as 20,000 birds.

Baker *et al.* (2005) found 7,570 red knots wintering in Maranhão, Brazil during an aerial census conducted in 2005. This number was a decline of only approximately 575 red knots reported for the same area in the mid-1980s by Morrison and Ross (1989), however birds were of very low weight. From preliminary analysis of band sightings at Maranhão, Baker *et al.* (2005) concluded that the wintering flocks at Maranhão are a separate population from that in Tierra del Fuego. Morrison *et al.* (2006) considers the red knots wintering in northern Brazil to be a separate biogeographical population from those wintering in southern South America.

Morrison *et al.* (2006) estimated the Florida / southeastern United States red knot wintering population in 2005 at about 7,500 individuals based on aerial survey data. During January 23 to February 19, 2006, 150 sites in Florida, Georgia, South Carolina, North Carolina, and Virginia were surveyed for red knots in the course of a U.S. Geological Survey piping plover (*Charadrius melodus*) survey, which is conducted every 5 years. A total of 4,569 red knots were counted in the five states, with the majority, 3,020 birds, found in Florida (Niles *et al.* 2006).

Records of migrating red knots have been collected at many sites along the Atlantic coast of the United States. Not all migration areas are well surveyed, and considerable turnover of individuals occurs as birds migrate through an area. Consequently, using counts of migrating red knots as a basis for population estimates is problematic due to errors associated with turnover or double-counting. However, counts made at a specific location are good indicators of usage trends for that area and may reflect trends in the overall population of the knot. A decline similar to that observed in wintering areas in South America has been observed within the red knot's principal North American spring migratory stopover area, the Delaware Bay of Delaware and New Jersey.

While the peak count of red knots observed at Delaware Bay is often described as the population estimate for the Bay, raw data from aerial surveys are not useful in estimating total populations of

shorebirds in the Bay due to unknown turnover and detection rates (U.S. Fish and Wildlife Service 2003). The shorebird survey methods used in the Delaware Bay can, however, be used to evaluate trends of migrating red knots. The aerial surveys provide comparative annual counts of numbers of red knots observed once per week during a 5-week survey period in May to early June (Clark *et al.* 1993). Peak aerial survey counts of migrating red knots on the Delaware Bay between 1982 and 1998 varied considerably, with highest recorded peaks of 95,360 and 94,460 birds occurring in 1982 and 1989, respectively, and lowest peak counts of 16,859 and 19,445 birds occurring in 1983 and 1996.

During the period of 1982 to 1998, aerial survey counts were somewhat cyclic where high peak years were generally followed by 1 to 2 years of declining peak counts followed by several years of rebounding peak counts (Dunne *et al.* 1983; Clark *et al.* 1993; Niles *et al.* 2005). However, from 1999-2004 red knot numbers in the Delaware Bay declined, reaching an all-time low peak count of 13,315 birds in 2004 (Niles *et al.* 2005). Although the 2005 peak count increased to 15,345 (Niles *et al.* 2005), the peak for 2006 was 13,455 (Clark 2006). Thus, although 2005 showed an increase, there has been an overall decline in the counts at Delaware Bay in recent years. Insufficient information is available to determine trends of migrating *C. c. rufa* in other areas of the Atlantic coastal United States.

Although many counts of spring migrant red knots have involved the Delaware Bay, as noted above, this provides an index of the status of the species using the Bay but does not necessarily represent the total population of spring migrants along the eastern seaboard. In 2005, for example, the peak aerial count for Delaware Bay was 15,345 red knots (Niles *et al.* 2005). However, in May 2005, an aerial survey for red knots along Virginia's barrier islands recorded an estimated 9,150 knots (Watts and Truitt 2005), and a peak count of approximately 20,000 red knots was reported on the same survey date from ground counts of an Atlantic coastal site in New Jersey, where most Delaware Bay red knots are believed to congregate at a nighttime roost (Sitters 2005). Thus, more red knots were accounted for during the spring 2005 migration than are reflected by the Delaware Bay peak aerial count for that year (Niles *et al.* 2005).

Based on an average fat-free mass of 130 grams(gm), upon arrival in Delaware Bay, red knots need to build fat reserves and achieve sufficient weight gain to reach a departure mass of at least 180 to 200 gm (threshold departure mass) just to cover the energetic costs of the flight to the breeding grounds and to survive an initial few days of snow cover (Baker *et al.* 2004). Baker *et al.* (2004) found that from 1997 to 2002 an increasing proportion of red knots leaving the Delaware Bay failed to achieve threshold departure masses; they attributed the decline in threshold departure mass to later arrival in the Bay and food shortages associated with commercial harvesting of horseshoe crabs. This reduced nutrient storage, especially in late-arriving birds, appears to have had severe fitness consequences for adult survival and recruitment of young in 2000 to 2002. From 1997 to 2002, known survivors in Delaware Bay were heavier at initial capture than birds never seen again. Annual survival declined from an average of 84.6 percent in the migration years of 1994/1995 through 1997/1998 to 56.4 percent in the migration years of 1997/1998 through 2000/2001 (Baker *et al.* 2004). Between May 2000 and May 2001

annual survival of adults decreased by 37 percent and the number of second year birds in wintering flocks declined by 47 percent (Baker *et al.* 2004).

Baker *et al.* (2004) analyzed 1997 to 2002 data from wintering populations in Tierra del Fuego and Patagonia and migrant red knots in the Delaware Bay to model annual survival of red knots. Assuming that adult survival in the future would average the pre-2000 level of 84.6 percent and a juvenile survival rate of half that of adults for 10 years from the year 2000, Baker *et al.* (2004) predicted that the red knot population would remain stable at roughly 70,000 birds through 2010. However, applying the 1997/1998 through 2000/2001 adult survival rate of 56.4 percent and juvenile survival rate of half that of adults, Baker *et al.* (2004) predicted that the population would decline to extremely low numbers (approaching zero) by 2010 (Baker *et al.* 2004). Counts of wintering populations of red knots in Tierra del Fuego and Patagonia in 2005 and 2006 showed a decline (Niles *et al.* 2005; Ross 2006) consistent with the trend predicted by Baker *et al.* (2004). However, the prediction by Baker *et al.* (2004) that the population would reach extremely low numbers by 2010, as well as the interpretation of the cause of the decline in the number of knots observed in recent winter counts, must be tempered by changes since 2002.

As noted above, the peak counts of red knots at Delaware Bay declined each year from 1999 to 2004. In 2004, following 5 years of reduced horseshoe crab harvest in the bay, the availability of horseshoe crab eggs on principal shorebird foraging beaches increased over previous years. In 2005 the peak count of migrant red knots in the Delaware Bay was 15,345, an increase over the 2004 peak of 13,315 and the first increase in the annual count for Delaware Bay since 1999 (Niles *et al.* 2005). Further, although red knots departed from the Delaware Bay in 2005 about 5 days later on average than in previous years, the majority of red knots reached satisfactory body weights (threshold departure mass) prior to departure (Minton and Taylor 2005). The 2006 surveys by the Canadian Wildlife Service of the principal South American wintering areas indicate that although the counts are at historic lows, there was only a minimal difference in the number observed in 2006 as compared to 2005 (Ross 2006). Taken together, this information from Delaware Bay and at key wintering areas suggests the possibility that the declining trend may have halted. While these numbers indicate that no further decline has occurred, numbers of red knots remain low and there has been no indication of recovery (Morrison pers. comm., 2007). The change in horseshoe crab management and the upturn in availability of eggs in 2004, and the finding that the majority of red knots reached satisfactory body weights prior to departure from Delaware Bay, also suggests that the conditions have changed in comparison to the 1997 to 2002 period used for the model of annual survival.

Another consideration involves conditions in the breeding habitat in 2004, which may have contributed to the decline in the number of knots observed at wintering areas in 2005 and 2006. At a site on Southampton Island in Canada, late snowmelt and adverse weather conditions, combined with predation, contributed to poor productivity in 2004 and may have also significantly increased mortality of adult red knots; Canadian researchers reported that most arctic-breeding birds failed to breed successfully in 2004 (Niles *et al.* 2005). Thus while the condition of knots leaving the Delaware Bay may be one of the reasons for the low numbers of wintering red knots observed in Tierra del Fuego and Patagonia in 2005 and 2006, the low

numbers observed also may be due, in part, to breeding failures and adult mortality in 2004 associated with unusual adverse weather conditions combined with predation (see "Disease and Predation" section, below).

THREATS

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Reduced Forage Base in Habitat at Delaware Bay Migration Stopover

Commercial harvest of spawning horseshoe crabs in the Delaware Bay, which results in reduced availability of horseshoe crab eggs, is a modification of habitat that is associated with the decline of the red knot. Reported commercial harvest of horseshoe crabs for the bait and biomedical industry increased dramatically in the Delaware Bay in the mid-1990s. In addition to harvest by trawl, crabs were hand-harvested as they ascended onto Delaware Bay beaches to spawn, coinciding with the period when migrating red knots and other shorebirds were foraging on crab eggs. Concern was raised about the negative effect that horseshoe crab harvest might have on shorebirds during migration (U.S. Fish and Wildlife Service 2003).

Long-distance migrant shorebirds are highly dependent on the continued existence, in good condition, of habitat at a few key staging areas. These areas serve as stepping stones to northerly breeding areas (International Wader Study Group 2003). The Delaware Bay of Delaware and New Jersey serves as the principal spring migration staging area for the red knot (Morrison and Harrington 1992; Harrington 1996; Harrington 2001; Niles *et al.* 2005). Conditions / factors influencing shorebird populations on staging areas such as the Delaware Bay control much of the remainder of the annual cycle and survival of the birds. Declining food resources and reduced suitability of staging areas have major implications for the survival and reproduction of these migrants (International Wader Study Group 2003).

From 1997 to 2002, Baker *et al.* (2004) found that an increasing proportion of red knots leaving the Delaware Bay failed to reach threshold departure masses of 180 to 200 gm, possibly because of later arrival in the Bay and food shortages from commercial harvesting of horseshoe crabs. This reduced nutrient storage, especially in late-arriving birds, had severe fitness consequences for adult survival and recruitment of young in 2000 to 2002: annual survival of adults decreased by 37 percent between May 2000 and May 2001 and the number of second-year birds in wintering flocks declined by 47 percent (Baker *et al.* 2004). We note, however, that the reduction in the number of second-year birds in wintering flocks, and the overall reduction in wintering populations, may also be partially due to cyclical changes in mortality of young due to predation (see discussion of "Disease or Predation," below).

Harvest of horseshoe crabs for the bait and biomedical industries has been implicated as a factor in declines of spawning horseshoe crabs within the Delaware Bay. In the late 1800s and early 1900s, horseshoe crabs were commercially harvested for use as fertilizer and livestock feed. Millions of crabs were harvested annually from the 1870s to the 1930s at which point

commercial landings appear to have dropped significantly. Commercial harvest of horseshoe crabs for fertilizer ceased in the 1960s (Atlantic States Marine Fisheries Commission 1998a). No information on how this historic harvest of horseshoe crabs may have affected populations of red knots or other migratory shorebirds is available.

Since the mid- to late 1900s, horseshoe crabs have been commercially harvested primarily for use as bait and to support a biomedical industry. Horseshoe crabs are the preferred bait in the mid-Atlantic for the American eel (*Anguilla rostrata*) and whelk and conch (Family Melongenidae) pot fisheries, and the crabs are also harvested to a lesser extent for use as bait in catfish (*Ictalurus* spp.) and killifish (*Fundulus* spp.) fisheries (Atlantic States Marine Fisheries Commission 1998a; 2004). Between 1970 and 1990, commercial harvest of horseshoe crabs on the Atlantic coast of the United States ranged from less than 20,000 pounds to above 2 million pounds annually. Reported harvest increased during the late 1990s to nearly 6 million pounds in 1997 and over 6.8 million pounds in 1998.

Prior to 1998, horseshoe crab harvests were unregulated in many States. Beginning in 1998, States were required to report the number of horseshoe crabs landed to the Atlantic States Marine Fisheries Commission (ASMFC). In 1998, over 2.7 million horseshoe crabs were landed on the Atlantic coast of the United States. Reported landings decreased to just over 1 million crabs in 2001 and 2003; preliminary reports for 2004 showed a drop in landings to under 650,000 crabs (Atlantic States Marine Fisheries Commission 2004; Meyers *et al.* 2005). For Delaware and New Jersey, the decline in horseshoe crab landings for bait is from 726,660 reported in 1999, to 173,777 reported in 2004.

In addition to their value in the bait industry, horseshoe crabs are vital to the biomedical industry for detection of bacterial endotoxins in pharmaceuticals. The major biomedical use of horseshoe crabs is the production of Limulus Amebocyte Lysate (LAL). The LAL is a clotting agent in horseshoe crab blood that allows detection of endotoxins pathogenic to humans in drugs and intravenous devices. The LAL test was commercialized in the 1970s and is currently the worldwide standard for screening medical equipment for bacterial contamination. In addition, horseshoe crab blood has recently been found useful in cancer research. Blood from horseshoe crabs is obtained by collecting adult crabs, extracting a portion of their blood, then releasing them alive. Estimates of the number of horseshoe crabs collected on the Atlantic coast for the biomedical industry range between 200,000 and 250,000 crabs per year (Atlantic States Marine Fisheries Commission 2004) and the mortality of bled crabs is reported to be less than 15 percent (15 percent mortality would be 30,000 – 37,500 crabs) although mortality due to shipping and handling the crabs is unknown.

In response to concerns that horseshoe crab harvest may have a negative effect on food resources for migrating shorebirds, the ASMFC prepared a Horseshoe Crab Stock Assessment (ASMFC1998a) and an Interstate Fishery Management Plan for Horseshoe Crab (ASMFC1998b). Beginning in 1999, the ASMFC imposed reduced State quotas for horseshoe crabs harvested for the bait industry, and quotas for New Jersey, Delaware, and Maryland were further reduced in 2004. In 2003, the State of New Jersey implemented restrictions on hand

harvest of horseshoe crabs and closed key Delaware Bay spawning / foraging beaches to public access. The State of Delaware implemented similar regulations in 2004.

In addition to the regulations already in effect for 2005, and in response to the late arrival of the red knots in Delaware Bay, New Jersey imposed an emergency moratorium temporarily halting the hand harvest of horseshoe crabs until June 23, 2005, to allow the birds continued unencumbered access to foraging areas. The State of Delaware also supplemented its regulations in 2005 by instituting mandatory horseshoe crab check stations, rather than voluntary check stations. Although the horseshoe crab harvest season in Delaware was scheduled to remain open until June 30, the State reached its 150,000 quota earlier, and closed all harvest effective June 24, 2005. With regulations passed in 2005, Delaware closed the 2006 harvest season from May 1 to June 7, 2006.

The ASMFC's Horseshoe Crab Management Board authorized the development of a draft addendum proposing a 2-year moratorium, with an exemption for harvest for biomedical use. The Management Board met in May 2006 and adopted restrictions effective from October 1, 2006 to September 30, 2008, including a prohibition on harvest and landing of horseshoe crabs in New Jersey and Delaware from January 1 through June 7, harvest of males only from June 8 through December 31, and harvest limited to no more than 100,000 horseshoe crabs per state per year. The ASMFC also adopted other restrictions applicable to Maryland and Virginia. New Jersey established restrictions in 2006 which supersede those of the ASMFC; as a result there is a moratorium on all horseshoe crab harvest in New Jersey from May 15, 2006 through June 7, 2008, after which the restrictions adopted by ASMFC apply. In February 2007, Delaware imposed a 2-year moratorium, effective January 1, 2007, on harvest of horseshoe crabs within Delaware lands or waters. This moratorium supersedes regulations imposed by ASMFC and will be in effect until December 31, 2008, after which any restrictions adopted by ASMFC will apply.

While management actions by the ASMFC have reduced harvest and will work toward increasing availability of horseshoe crab eggs for migrating shorebirds in the long-term, significant benefits of these management actions will not be realized immediately. The horseshoe crab is relatively long-lived and slow to mature, reaching breeding age at about 10 years of age; thus there would likely be at least a 10-year lag time between fishery restrictions and the full effect of changes in horseshoe crab populations (ASMFC 2004). It may be difficult to determine changes in horseshoe crab populations even when they occur. An initial horseshoe crab stock assessment concluded in 1998 that there was insufficient information available for a coastwide assessment of horseshoe crab populations. Earlier data suggested that the horseshoe crab population in the mid-Atlantic region was stable or declining (ASMFC1998a), but additional attempts to assess coast-wide or regional horseshoe crab populations have been highly variable, with low power to detect population changes; at present it is only possible to detect dramatic changes in population size (ASMFC 2004). A redesigned Delaware Bay horseshoe crab spawning survey showed that spawning activity was stable or slightly declining from 1999 to 2004 (Meyers *et al.* 2005). A surplus production model study by Davis *et al* (In press) concluded that the horseshoe crab population in the Delaware Bay region has been depleted and 2004 harvest levels may be too high to allow the population to rebuild.

Surveys of horseshoe crab eggs on beaches in New Jersey showed a significant decline in the density of eggs in the upper 5 cm of sand for the period of 1996 to 2005 as compared to egg counts from the mid-1980s and early 1990s (Niles *et al.* 2005). This decline would affect red knots more significantly than other shorebird species since red knots feed on surface eggs rather than probing deeply like some other shorebird species (Tsipoura and Burger 1999). Typically, eggs are laid by horseshoe crabs at depths that would make them unavailable to foraging red knots, but the action of multiple female crabs nesting within a particular beach exhumes eggs onto the surface making them available to foraging red knots (Brockmann 2006). When numbers of spawning horseshoe crabs are reduced, insufficient “churning” of sediments containing previously laid nests occurs, preventing eggs from being exposed at the surface. Various foraging studies have shown that an individual red knot needs to consume between 13,000 and 30,000 horseshoe crab eggs per day during the Delaware Bay stopover to build fat reserves to meet the energetic requirements of migration to and surviving the first few days on Arctic breeding areas (Haramis *et al.* In press 2007; Niles *et al.* 2005). Haramis *et al.* (In press 2007) calculated that a population of 40,000 red knots, requiring an average 80-gm increase in body mass per bird to reach migratory condition, would need to consume an estimated 16 billion horseshoe crabs eggs during the Delaware Bay stopover period. Thus, there must be very high numbers of female horseshoe crabs nesting synchronously in order to provide the superabundance of surface eggs needed to support migrating red knots (Haramis *et al.* In press 2007; Brockmann 2006).

Decreased Habitat Availability from Beach Erosion and Shoreline Stabilization

Sea level rise and shoreline erosion have reduced availability of intertidal habitat that is used for horseshoe crab spawning and red knot foraging within the principal migration stopover area of the Delaware Bay. In addition, erosion has also led to loss of sites used by red knots for roosting, especially around the Mispillion Harbor portion of the Bay (Niles *et al.* 2005).

The Delaware Bay’s sandy beaches are dynamic, migrating landward from storm overwash and retreating landward in the face of continued sea level rise. While future rates are hard to predict, the current level of sea level rise in the Delaware Bay in New Jersey is generally thought to be about 3 millimeters per year (Phillips 1986a). This change has resulted in erosion of the Bay’s shorelines and a landward extension of the inland edge of the marshes. During 1940-1978, Phillips (1986a) documented a mean erosion rate of 3.2 meters per year for a 52-km long section of New Jersey’s Delaware Bay Cumberland County shoreline and indicated that this was a high rate of erosion compared to other estuaries. The spatial pattern of the erosion was complex, with differential erosion resistance related to local differences in shoreline morphology (Phillips 1986b). Phillips’ shoreline erosion studies (1986a, 1986b) suggest that bay-edge erosion is occurring more rapidly than the landward/upward extension of the coastal wetlands and that this pattern is likely to persist.

Galbraith *et al.* (2002) examined several different scenarios of future sea level rise and projected major losses of intertidal habitat in Delaware. Under the 50 percent probability scenario,

Delaware Bay is predicted to lose 20 percent or more of the shorebird intertidal feeding habitats by 2050 and 57 percent or more by 2100. Under more extreme sea level rise, Delaware Bay may actually have a net gain of intertidal flats as the coastline migrates further inland, converting dry land to intertidal (Galbraith *et al.* 2002). However, this prediction assumes that coastal protection structures do not constrain the ability of shorelines to migrate landward (Niles *et al.* 2005).

Within the Delaware Bay system, as elsewhere in the Mid-Atlantic region, coastal development and shoreline protection activities are expected to interfere with the longer-term landward migration of shorelines (Najjar *et al.* 2000; Niles *et al.* 2005). Though Delaware Bay is less developed than many similar stretches of Mid-Atlantic coastline, some optimal crab-spawning beach habitat is also the site of existing shoreline residential development. Significant sections of the Delaware Bay shoreline have already been impacted by shoreline protection/stabilization projects. Coupled with continuing sea level rise and shoreline erosion, the demand for additional shoreline protection structures is expected to increase (Najjar *et al.* 2000; Niles *et al.* 2005). Shoreline stabilization or armoring projects employing bulkheading, riprap or other solid beach-fill can either completely eliminate intertidal sand beach habitat or sufficiently alter sediment quality and beach morphology to negatively affect the suitability of the remaining habitat for horseshoe crab spawning (Botton *et al.* 1988; Niles *et al.* 2005).

Beach replenishment through offshore pumping of sandy sediments (as carried out along several sections of the Delaware shore, but not New Jersey) provides an alternative means of beach stabilization as well as creating potential crab-spawning habitat. However, the value of beach replenishment as a crab-spawning habitat restoration strategy has not yet been fully evaluated (Niles *et al.* 2005).

Niles *et al.* (2005) also identified shoreline stabilization and/or beach replenishment as a threat to red knot foraging or roosting habitat in Massachusetts and North Carolina. In Florida, shoreline hardening, dredging, and beach nourishment activities are significantly altering much of the coastline, decreasing the amount of available red knot foraging habitat. Similarly, beach raking activities in Florida alter the natural characteristics of the beach zone diminishing red knot habitat suitability.

Impacts to Habitat in South America

Niles *et al.* (2005) consider offshore petroleum exploration on the continental shelf, as well as iron ore and gold mining, to be among the most important threats to red knots in Brazil. These activities lead to loss of coastal habitat through the dumping of soil, oil pollution, mercury contamination, and uncontrolled spread of urban development along the coast. Clearing of mangroves and fishing activities are among other disturbances that have had a negative impact on red knot habitat in Brazil. (Niles *et al.* 2005). Specific information on the extent of these impacts is not currently available.

Lagoa do Peixe National Park in Brazil is one of the largest stopover areas for North American migratory birds on the South American continent. The lagoon serves as a major foraging area for red knots. Farmers draining water from farm fields into the lagoon and impacts of erosion and lowering of the water table from adjacent pine (*Pinus* spp.) plantations alter the lagoon's natural fluctuations and the coastal processes that allow annual connection of the lagoon with the sea. The abundance and availability of the red knot's food supply are dependent on the lagoon's water levels (Niles *et al.* 2005).

In Argentina, Niles *et al.* (2005) cited oil pollution as a concern at the Reserva Provincial de Río Chico para Aves Playeras Migratorias and Reserva Urbana Costera del Río Chico, at Bahía Bustamante, and at Península Valdés. At the Bahía San Antonio Natural Protected Area (created in 1993) there is major potential for pollution from a soda ash factory which began to operate in 2005, and from port activities. Development and associated pollution are concerns at the Reserva Provincial de Río Chico para Aves Playeras Migratorias (created in 2001) and Reserva Urbana Costera del Río Chico (created in 2004). Impacts to these areas include degradation of red knot habitat from filling of tidal flats and marshes for urban use, location of a rubbish dump near shorebird feeding and roosting sites and pollution from urban waste (Niles *et al.* 2005).

At the principal red knot wintering site in Bahía Lomas, Chile, onshore and offshore oil extraction has had a negative impact on red knots and their habitat. Two past oil spill incidents have been recorded in the vicinity: 53 tons from the *Metula* in 1974 and 100 tons from the *Berge Nice* in 2004. New Jersey Endangered and Nongame Species Program staff noted oil on some birds caught during banding activities at Bahía Lomas in 2005 (Niles *et al.* 2005), but the source or amount of released oil or total number of red knots affected is unknown. The magnitude of impact from oil pollution on the red knot and its habitat from past spills is not known; however, since Bahía Lomas supports the majority of wintering red knots in South America (Niles *et al.* 2005; Ross 2006), a major oil spill at this site could have a substantial negative impact on the species.

Most of the sites used by red knots at Río Grande on the Atlantic coast of the Argentinean part of Tierra del Fuego are within the Reserva Costa Atlántica de Tierra del Fuego, created in 1992. As at Bahía Lomas, the area is important for on- and off-shore oil production with the potential for oil pollution, especially from oil tankers loading around Río Grande City. There is no direct evidence of red knots having been affected by oil pollution, but it remains a potential risk to the knots and their wintering habitat.

No changes in habitat or increased threats were evident on the wintering areas surveyed by the Canadian Wildlife Service in 2007 (Ross pers. comm., 2007).

In summary, commercial harvest of spawning horseshoe crabs in Delaware Bay has substantially modified the habitat of the red knot by altering the availability of horseshoe crab eggs, a key food resource and source of energy for the knot as they migrate to breeding areas. Research has shown that an increasing proportion of red knots leaving the Delaware Bay had reduced threshold departure body mass, which appears to have contributed to reduced adult survival and reduced

recruitment of young between May 2000 and May 2001. Although the ASMFC and the States of Delaware and New Jersey have been taking steps to reduce the commercial harvest, it is not clear whether the reduction is sufficient to allow horseshoe crab populations to rebuild. The peak counts of knots at Delaware Bay increased in 2005 in comparison to 2004, and the 2006 peak count was similar to that of 2004, and the count in key wintering areas in southern South America were only slightly lower in 2006 as compared to 2005; these results are a sign that the declining trend might have ceased or slowed. However, the overall trend has been substantially negative over a period of several years, and the rebound in populations that was observed in prior years has not occurred.

In addition to the problems associated with the decrease in horseshoe crab eggs, intertidal habitat used by red knots for foraging in Delaware Bay is being destroyed or modified due to beach erosion. Erosion is occurring as a result of the combined effect of storms and a continued increase in sea level, and continued increases are predicted in association with global climate change. Intertidal foraging habitat also is being destroyed due to various shoreline protection/stabilization projects that either completely eliminate intertidal sand beach habitat or modify it to negatively impact suitability for horseshoe crab spawning. It is not clear that beach replenishment will be an alternative means of beach stabilization or whether it will result in suitable crab-spawning habitat. There also is on-going and threatened habitat destruction and modification in other areas used by migrating red knots along the Atlantic Coast in the United States, and in some wintering habitats in South America, but we are not able to determine the impact to the red knot of the habitat loss in these other areas.

Based on consideration of the available information, we conclude that the present and threatened destruction, modification, and curtailment of habitat, particularly in the Delaware Bay, is a basis for a proposed rule listing the *rufa* subspecies of the red knot.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

Red knots were heavily hunted for both market and sport during the second half of the nineteenth and first quarter of the twentieth centuries. For example, market hunters in Massachusetts may have taken up to 4,000 red knots in a single night (Harrington 2001). However, hunting red knots is no longer allowed in the United States.

Band recoveries indicate that knots are killed commonly for food in some regions of South America, especially the Guianas. Red knots are also shot for sport in Barbados. Information from band recoveries indicates that the take may be substantial (Harrington 2001), but the overall take and its impact on the subspecies is unknown.

Hunting migratory shorebirds for food was once common among local communities in Maranhão, Brazil. Shorebirds provided an alternative source of protein and birds with high subcutaneous fat content, such as those birds found at staging areas building up reserves for long migratory flights, were particularly valued. According to locals, the most consumed species were red knot, black bellied plover (*Pluvialis squatarola*) and whimbrel (*Numenius phaeopus*), though

no data are available as to the number of birds taken. Local people say that although some shorebirds are still hunted, this has greatly decreased over the past decade (Niles *et al.* 2005).

Based on the available information, overutilization for commercial, recreational, scientific, or educational purposes is not a basis for proposing to list the *rufa* subspecies of the red knot.

C. Disease or predation.

Niles *et al.* (2005) described an introduced breeding population of peregrine falcons (*Falco peregrinus*) as a threat to red knots in Virginia, where peregrines caused frequent interruptions to red knot foraging and roosting. Similarly, several pairs of peregrine falcons on the New Jersey side of the Delaware Bay use artificial nesting structures in proximity to red knot migratory habitats. While the falcons may pose a risk to some individual red knots, we do not have any information that suggests they pose a risk to the overall population of red knots. Other likely predators of migrating red knots in New Jersey include red fox (*Vulpes vulpes*) and feral cats (*Felis silvestris*) (Niles *et al.* 2005). No information regarding the magnitude of such predatory impacts is available.

In the Arctic, 3- to 4-year lemming cycles give rise to similar cycles in the predation of shorebird nests. When lemmings are abundant, arctic foxes (*Alopex lagopus*) and jaegers (*Stercorarius* spp.) concentrate on the lemmings and shorebirds breed successfully. When lemmings are in short supply, few shorebird eggs or chicks survive (Underhill 1993). These cycles have always affected the productivity of arctic-breeding shorebirds and lead to fairly minor year-to-year changes in otherwise stable populations. Unsuccessful breeding seasons have contributed to at least some of the observed recent reductions in the red knot population (Niles *et al.* 2005) and can be expected to lead to cyclic losses in future years. The cyclical nature of this predation on shorebirds is a situation that probably has occurred over many centuries and under historic conditions probably had no lasting impact on red knot populations. While there apparently was widespread lack of breeding success in 2004 that was attributed in part to predation, there is no indication that this was anything other than one of the events that happens from time to time and we have no basis for concluding that predation during the breeding season is having a long-term impact on persistence of red knots.

We have limited information on disease (including the impact of parasites) in relation to the red knot. An epizootic disease resulting in large-scale mortality of knots reported from the west coast of Florida in December 1973 and November 1974 was caused by a protozoan parasite, most likely an undescribed sporozoan species (Harrington 2001). Further reports on knot mortality in Florida in 1981 were due to the blood parasite *Plasmodium hermani* (Harrington 2001).

In 1981 there was a report of an adventitious molt in knots caused by a mallophagan parasite (Mallophaga: Menoponidae) in feather shafts (Harrington 2001).

On 7 April 1997, 26 red knots, 10 white-rumped sandpipers (*Calidris fuscicollis*) and 3 sanderlings (*C. alba*) were found dead or dying along 10 km of beach at Lagoa do Peixe in

southern Brazil. The following day, another 13 dead or sick knots were found along 35 km of beach nearby. Some, but not all of these birds, were infected with hookworms (*Acanthocephala* spp.). Although hookworms can cause death, it would seem more likely that the mortality had another cause. Smaller mortalities of spring migrants with similar symptoms have also been reported from Uruguay in recent years (Niles *et al.* 2005).

Since 2002, migratory birds in Brazil have been tested for viruses including West Nile, Newcastle, and avian influenza by the National Health Foundation in collaboration with Instituto Brasileiro do Meio Ambiente dos Recursos Naturais Renováveis and Centro Nacional de Pesquisa para Conservação das Aves Silvestres. To date, avian influenza type H2 has been found in one red knot, Mayaro virus in seven knots, and Equine Encephalite virus in another (Niles *et al.* 2005).

Since December 2003, blood and feather samples have been collected in Brazil from red knots and several other shorebird species for genetic variability studies and stable isotope analysis. In the course of these studies in February 2005, all 38 knots caught and sampled in Maranhão were found to be heavily infected with ectoparasites. The birds were also extremely light, less than the usual fat-free mass of knots (Baker *et al.* 2005).

No systematic effort has yet been made to assess the parasite load of birds passing through Delaware Bay, but fieldworkers have noticed ectoparasites on a substantial number of knots caught there (Niles *et al.* 2005).

Based on the available information, disease and predation are not a basis for proposing to list the red knot.

D. The inadequacy of existing regulatory mechanisms.

The Migratory Bird Treaty Act (40 Stat. 755; 16 U.S.C. 703-712) (MBTA) is the only current federal protection provided for the red knot. The MBTA prohibits "take" of any migratory bird, which is defined as: "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect." However, other than for nesting sites, which are not located in the United States, the MBTA provides no authority for protection of habitat or food resources. Human disturbance is cited as one of the major threats to red knots throughout its migratory range within the United States. The MBTA does not afford red knots protection from human disturbance on migratory and wintering areas.

Starting in 2003, major sections of the New Jersey shoreline of the Delaware Bay have been closed to human use during the peak of the stopover at the initiative of the New Jersey Division of Fish and Wildlife in order to reduce disturbance to shorebirds by people and dogs. No similar closures have been instituted in Delaware.

In response to concern for impacts to the red knot and other migratory shorebirds, the ASMFC adopted a Fishery Management Plan for the Horseshoe Crab in 1998. Beginning in 1999, the

ASMFC imposed reduced State quotas for horseshoe crabs harvested for the bait industry; quotas in the states of New Jersey, Delaware, and Maryland were further reduced in 2004. In 2003, the State of New Jersey implemented restrictions on hand harvest of horseshoe crabs and closed key Delaware Bay spawning / foraging beaches to public access. The State of Delaware implemented similar regulations in 2004.

In 2005, the States of New Jersey and Delaware took additional regulatory action to ensure that the horseshoe crab harvest did not adversely impact the red knot or other migratory shorebirds. In addition to the regulations already in effect for 2005, and in response to the late arrival of the red knots in Delaware Bay, New Jersey imposed an emergency moratorium temporarily halting the hand harvest of horseshoe crabs until June 23, 2005, to allow the birds continued unencumbered access to foraging areas.

The State of Delaware also supplemented its regulations in 2005 by instituting mandatory horseshoe crab check stations, rather than voluntary check stations. Although the horseshoe crab harvest season in Delaware was scheduled to remain open until June 30, the State reached its 150,000 quota earlier, closing all harvest effective June 24, 2005. Delaware closed the harvest season from May 1 to June 7, 2006.

In the fall of 2005, the States of Delaware and New Jersey addressed the ASMFC and proposed a 2-year moratorium on horseshoe crab harvest in the Delaware Bay. The ASMFC's Horseshoe Crab Management Board authorized development of a draft addendum proposing the 2-year moratorium, with an exemption for harvest for biomedical use. The Management Board met in May 2006 to review public comment and consider approval of the draft addendum. The Board approved the following harvest restrictions effective from October 1, 2006 to September 30, 2008: (1) for New Jersey and Delaware there is a prohibition on harvest and landing of horseshoe crabs from January 1 through June 7, harvest of males only is allowed from June 8 through December 31, and harvest is limited to no more than 100,000 horseshoe crabs per state per year; (2) in Virginia, the harvest season is closed from January 1 through June 7, 40% of harvest must be from outside state waters, and there is a minimum male to female ration of 2:1; and (3) in Maryland the season is closed from January 1 through June 7. New Jersey has established restrictions which supersede those of the ASMFC; as a result there is a moratorium on all horseshoe crab harvest in New Jersey from May 15, 2006 through June 7, 2008, after which the restrictions adopted by ASMFC apply. In February 2007, Delaware imposed a 2-year moratorium, effective January 1, 2007, on harvest of horseshoe crabs within Delaware lands or waters. This moratorium supersedes regulations imposed by ASMFC and will be in effect until December 31, 2008, after which any restrictions adopted by ASMFC will apply.

We are encouraged by the States' efforts to restrict horseshoe crab harvest. We believe that continued restrictions at appropriate times and appropriate levels will contribute to the conservation of the red knot. However, we do not know precisely whether measures described above will be sufficient in the long term to result in restoration of horseshoe crab populations to levels that will result in the abundance of eggs needed for migrating red knots as they increase their body mass prior the breeding season.

In summary, recent changes in regulations pertaining to limits on commercial harvest of horseshoe crab should help stabilize or restore the crab population and the availability of eggs as a food source for the red knot, but this remains to be seen. Existing regulatory mechanisms also have not been adequate to address the destruction and modification of intertidal foraging habitat due to erosion and shoreline stabilization involving the Delaware Bay area.

E. Other natural or manmade factors affecting its continued existence.

Curtailement of Habitat Use by Human Disturbance

Human disturbance can have an adverse effect on foraging by shorebirds at available suitable habitats. The severity of the impact depends on the degree of disturbance and the availability of other suitable feeding areas. Disturbance compels birds to pay the energetic cost of flying to a new area; it may reduce the amount of time that the birds are able to feed, and can prevent them from feeding in the most preferred sites. Disturbance, however, may have little impact on birds if suitable alternate foraging areas are nearby in which the birds can feed (Niles *et al.* 2005).

The annual spectacle of shorebirds and spawning horseshoe crabs draws hundreds of bird watchers to Delaware Bay beaches during the spring migratory stopover. Ecotourism in the Delaware Bay has increased since the 1980s and is expected to continue to increase in future years. Negative impacts from ecotourism on shorebirds included disturbance of resting and foraging birds, shifting of use from optimal foraging sites to less disturbed but less suitable sites, and decreasing flock sizes on heavily disturbed beaches (Burger *et al.* 1995). The beaches are also vulnerable to the usual beach activities, such as walking, jogging, fishing and dog walking (Niles *et al.* 2005). Disturbance along the New Jersey shore of Delaware Bay was first investigated in 1982, with further studies in the 1980s, 1990 and 2002 (Burger *et al.* 2004). The results show that the average period that a beach was disturbed during any hour of the day dropped from 32.9 minutes in 1982 to 3.2 minutes in 2002. This decrease was the direct result of increased management efforts by the New Jersey Division of Fish and Wildlife. However, throughout most of the red knot's range, no similar protection from human disturbance is provided to migrating or wintering red knots.

One measure of sensitivity to disturbance is whether the birds return to an area after being disrupted. When shorebirds foraging on beaches are disturbed by people and dogs, the birds usually respond by flying away. In 1982, 30 percent of shorebirds disturbed at Reeds Beach South and 98 percent at Reeds Beach North in New Jersey flew away when disrupted by people and did not return within 10 minutes. In 2002, 98 percent of shorebirds disturbed at Reeds Beach South and 93 percent at Reeds Beach North did not return, with an increasing proportion of disturbance coming from dogs (Burger *et al.* 2004). Burger *et al.* (2004) found that shorebirds flew away and did not return to forage in response to 58 percent or more human disruptions.

In New Jersey, when most beaches were protected from disturbance in 2002, the shorebirds were able to move to nearby beaches that were undisturbed. Therefore, management that restricts

human activities on Delaware Bay beaches is shown to be effective in creating disturbance-free beaches necessary for feeding and resting shorebirds. Starting in 2003, major sections of the New Jersey shoreline of the Delaware Bay have been closed to human use during the peak of the stopover at the initiative of the NJDFW in order to reduce disturbance to shorebirds by people and dogs. Before this, disturbance of the beaches was a particular problem, especially during Memorial Day weekend (Niles *et al.* 2005). In 2001, for example, all 18,000 red knots that had previously been feeding on the bayshore spent Memorial Day weekend on the Atlantic coast in the vicinity of Stone Harbor (Sitters 2001) where the birds have been observed feeding on mussel spat, an alternate food source that does not provide the same caloric benefit as fat-rich horseshoe crab eggs.

Similar bay-wide closures of human activities on horseshoe crab spawning/shorebird feeding beaches have not been implemented in Delaware where human disturbance of foraging red knots continues in some locations (Bennett 2005). An additional source of human-induced disturbance in Delaware is that caused by off-road vehicle (ORV) use. Although not quantified, shorebird foraging areas within the Delaware shore of the Bay are occasionally used by ORVs. The frequency and duration of this type of disturbance varies, but can have a major impact if ORVs remain at a specific location for an extended period of time. An ORV driving along a beach without stopping may have a relatively insignificant effect. However, when they are used with great frequency or for long periods (such as when ORVs are used for recreation as opposed to transportation), they probably cause shorebirds to leave and not return (Niles *et al.* 2005). With the decrease in numbers of horseshoe crabs and increased loss of available horseshoe crab spawning habitat due to erosion, fewer highly suitable foraging sites are available to red knots. Human disturbance causes disruption of resting and foraging birds and shifting of use from optimal foraging sites to less suitable sites; this could negatively impact the ability of the birds to attain the weight gain needed to for migration to the Arctic and successful breeding there.

Disturbance by people is not limited to direct use of Delaware Bay beaches. Low energy beaches, particularly those along the mouths of tidal creeks and rivers, have been identified as optimum horseshoe crab spawning habitat. Where these areas have high levels of boat traffic, such as at Mispillion Harbor in Delaware, disturbance due to the presence, noise, speed, or wake of boats is likely to be considerable (Niles *et al.* 2005). Preliminary results indicate that boat traffic in Mispillion Harbor represents a significant source of disturbance to feeding shorebirds, particularly when boats travel at high speed. Mispillion Harbor consistently supports high concentrations of red knots, sometimes more than 20 percent of the entire Delaware Bay population (Niles *et al.* 2005).

As in the principal migration Delaware Bay stopover area, human disturbance within otherwise suitable red knot migration and winter foraging or roosting areas was reported by biologists as a major negative impact to red knots in Massachusetts, Virginia, North Carolina, South Carolina, Georgia, and Florida. Disturbance in Florida was characterized as chronic with most beaches experiencing very high and increasing rates of disturbance (Niles *et al.* 2005).

In summary, studies have shown that human disturbance causes a substantial disruption to foraging and resting red knots. When coupled with diminished prey resources and reduced habitat availability, such human disturbance displaces red knots from optimal foraging sites to areas that may be less suitable. Therefore, the available information suggests that human disturbance occurring during critical migration periods can result in a negative impact and, while not the primary cause, may be a contributing factor to reduced fitness of red knots. The amount of disturbance may have decreased in some key areas due to closures, but this is unclear.

Gull competition

Botton (1984) noted that in addition to shorebirds, large populations of laughing gulls were predominant on horseshoe crab spawning beaches in Delaware Bay. During 1992-2002, the number of gulls recorded in single-day counts on Delaware Bay beaches in New Jersey ranged from 10,000 to 23,000 (Niles *et al.* 2005). Gull breeding colonies in Delaware are not located as close to the bayshore beaches as in New Jersey. However, immature, non-breeding, large gulls such as greater black-backed gull (*Larus marinus*) and herring gull (*L. argentatus*) and some laughing gulls (*L. atricilla*), most likely from New Jersey breeding colonies, do congregate on the Delaware shore during the spring, especially at Mispillion Harbor (Niles *et al.* 2005).

Gulls foraging on the beaches of Delaware Bay may directly or indirectly compete with shorebirds for horseshoe crab eggs. Burger *et al.* (1979) found that intraspecific aggressive interactions of shorebirds were more common than interspecific interactions. Negative interactions between knots and laughing gulls that resulted in disruption of knot behavior were no more prevalent than interactions with ruddy turnstones (*Arenaria interpres morinella*), short-billed dowitchers (*Limnodromus griseus griseus*), or black-bellied plovers (*Pluvialis squatarola*). However, larger-bodied species tended to successfully defend areas against smaller species. Total aggressive interactions increased as density of birds increased in favored habitats, which indicated some competition for food resources. Sullivan (1986) found that aggression in ruddy turnstones increased as experimentally-manipulated food resources (horseshoe crab eggs) changed from an even distribution to a more patchy distribution. Decisions to defend food patches were likely driven by the cost of locating new patches. The implications of this information for the knot are unclear at this time.

Following up on earlier results, Burger (In press) studied foraging behavior in shorebirds and gulls at Delaware Bay, New Jersey, during spring migration to determine if interference competition existed between shorebirds and gulls. In general, shorebirds have conspecifics as their nearest neighbors and, thus, fed in conspecific groups. Similarly, laughing gulls usually fed among conspecifics. Interference competition occurs in foraging flocks if there is a change in feeding rate of a focal bird when it feeds in the presence of different numbers of competitors, or with different species. For knots, the time devoted to foraging when gulls were present was significantly less than when a nearest neighbor was any shorebird. Red knots spent more time being vigilant when their nearest neighbors were gulls rather than other shorebirds. Similarly, knots engaged in more aggression when gulls were nearest neighbors (although they usually lost) (Burger, In press; U.S. Fish and Wildlife Service 2003).

Reduction of available horseshoe crab eggs or consolidation of spawning crabs onto fewer beaches could increase interference competition among egg foragers. Botton *et al.* (1994) noted that flocks of shorebirds appeared to be deterred from landing on beaches when large flocks of gulls were present. Red knot foraging efficiency is also adversely affected by the mere presence of gulls: Hernandez (2005) found that the foraging efficiency of knots feeding on horseshoe crab eggs decreased by as much as 40 percent when feeding close to a gull.

Gulls are more tolerant of human disturbance than shorebirds. When disturbed by humans, gull numbers returned to pre-disturbance levels within 5 minutes. Even after 10 minutes, shorebird numbers failed to reach pre-disturbance levels. Thus, the size and aggression of gulls, coupled with their greater tolerance of human disturbance, give gulls an advantage over shorebirds in prime feeding areas.

In the present scenario of limited availability of good feeding beaches, competition for food with gulls appears to be an increasing negative impact on red knots in the Delaware Bay (Niles *et al.* 2005). However, we do not know whether the impacts are occurring at levels sufficient to pose a threat to the persistence of the red knot.

Weather

Adverse weather in the Arctic can cause years with little to no productivity. At a site on Southampton Island in Canada (where breeding red knots have been studied since 1999 by the New Jersey Endangered and Nongame Species Program), late snowmelt and adverse weather conditions, combined with predation, contributed to poor productivity in 2004 and may have also significantly increased mortality of adult red knots (Niles *et al.* 2005). Canadian researchers reported that most arctic-breeding birds failed to breed successfully in 2004 (Niles *et al.* 2005). In 2006, within red knot breeding areas in the eastern Arctic and Hudson Bay, Arctic weather conditions were normal to above normal (Canadian Ice Service 2006). Variations in weather are a natural occurrence and normally are not considered as a threat to the persistence of a species unless the number of individuals is reduced to a very low level and they are concentrated in an area that is subject to weather conditions that result in mortality and/or poor productivity.

Risk of Small Population Size

Genetic studies indicate that small populations are especially vulnerable to the accumulation of harmful genetic mutations (genetic drift), and that "effective population sizes" are significantly smaller than "census population sizes". Not all individuals in a population contribute to the gene pool. Owing to the low genetic variability of wading bird species, concern has been expressed regarding the long-term genetic consequences of populations falling below 15,000 individuals (International Wader Study Group 2003). Based on what we know of red knot populations at this time (e.g., winter counts and counts in spring migration areas), they have experienced a decline but the population was substantially greater than 15,000 birds in 2005. Specifically, in May 2005, a combined total of nearly 30,000 birds were observed on the same day during an aerial

survey along Virginia's barrier islands (Watts and Truitt 2005) and a ground count at a coastal site in New Jersey where most knots that feed on Delaware Bay are believed to congregate (Sitters 2005); this does not include knots in other areas along the Atlantic Coast, which would further increase the minimum number of knots. Also, genetic drift problems that rise to the level of threatening the persistence of a species tend to occur only with extremely small populations. Therefore, we do not believe there is a risk of harmful genetic mutation that threatens the persistence of the red knot at this time.

CONSERVATION MEASURES PLANNED OR IMPLEMENTED

In response to concern for impacts to the red knot and other migratory shorebirds, the ASMFC adopted a Fishery Management Plan for the Horseshoe Crab in 1998. Beginning in 1999, the ASMFC imposed reduced State quotas for horseshoe crabs harvested for the bait industry. See the discussion above concerning regulatory mechanisms (factor D) for a description of restrictions on horseshoe crab harvest.

Starting in 2003, major sections of the New Jersey shoreline of the Delaware Bay have been closed to human use during the peak of the stopover at the initiative of the New Jersey Division of Fish and Wildlife in order to reduce disturbance to shorebirds by people and dogs.

In May 2006, a key land parcel within Mispillion Harbor, Kent County, Delaware was purchased for protection of red knots and other shorebirds by The Conservation Fund, based in Arlington, Virginia with a Mid-Atlantic office in Wilmington, Delaware. This parcel, spanning approximately 1 mile of shoreline at Mispillion Harbor, provides prime horseshoe crab spawning / red knot foraging habitat during the annual spring migratory stopover (Kevin Kalasz, pers comm. 2006).

SUMMARY OF THREATS

Although small in relation to the taxon's entire range, the habitat at Delaware Bay plays a crucial role in the persistence of the *rufa* subspecies of the red knot. A large proportion of migrating red knots use the Delaware Bay as a staging area on their northward migration in the spring. The abundance and availability of horseshoe crab eggs in the intertidal foraging habitat used by red knots in Delaware Bay is key to building fat reserves considered crucial for sustaining red knots on their nonstop flight from the Delaware Bay and for survival and successful reproduction on arctic breeding grounds. A major threat to the *rufa* subspecies of the red knot is the present and threatened destruction, modification, and curtailment of its habitat through the reduction in horseshoe crabs, and thus the abundance of horseshoe crab eggs at the principal migratory stopover area in the Delaware Bay of Delaware and New Jersey. Erosion related to rising sea levels; and shoreline stabilization, also is contributing to the threat of destruction and modification of intertidal foraging habitat in the Delaware Bay. Although erosion and shoreline stabilization projects also are impacting habitat used by migrating knots elsewhere along the Atlantic Coast, we lack sufficient information on the scope and scale of habitat destruction and

modification for migrating red knots, and the impacts to the species, for areas other than the Delaware Bay.

Recent changes in regulations pertaining to limits on commercial harvest of horseshoe crab may help stabilize or restore the crab population and the availability of eggs as a food source for the red knot, but this remains to be seen. To date, existing regulatory mechanisms have been inadequate to ensure horseshoe crab populations are at levels sufficient to produce the abundance of horseshoe crab eggs that are crucial to build up fat reserves considered crucial for sustaining red knots on their nonstop flight from the Delaware Bay and for survival and successful reproduction on arctic breeding grounds. Existing regulatory mechanisms also have not been adequate to address the destruction and modification of intertidal foraging habitat due to erosion and shoreline stabilization involving the Delaware Bay area.

The impacts of competition from gulls and human disturbance to red knots within foraging and roosting habitats are unclear. They may be contributing to reduced fitness of individual red knots, but we do not know whether such impacts are occurring at sufficient levels to pose a threat to the persistence of the subspecies. We note also that some measures have been taken to reduce human disturbance in the New Jersey portions of the Delaware Bay.

Disease and predation do not appear to pose threats to the persistence of the red knot.

Impacts to wintering red knots in South America include past and potential habitat destruction and modification due to oil spills at wintering concentration areas, hunting, exposures to epizootic disease, and parasitic infestations. We do not have sufficient information on the size and scope of any of these ongoing or potential impacts in the South American wintering areas to conclude that they pose a threat that would be part of a basis for concluding that the species warrants listing under the Endangered Species Act.

In summary, based on our assessment of the life history and status of the red knot, we conclude that the present and threatened destruction and modification of habitat, particularly in the Delaware Bay, and the inadequacy of existing regulatory mechanisms related to habitat destruction and modification, pose significant risks to the *rufa* subspecies of the red knot. Therefore, we conclude that we have on file sufficient information on biological vulnerability and threats to support a proposal to list the *rufa* subspecies of the red knot (*Calidris canutus rufa*) under the Endangered Species Act of 1973. Although listing this subspecies is warranted, preparation and publication of a proposal is precluded by higher-priority listing actions. Thus, the red knot meets our definition of a species that is a candidate for listing.

The Service finds that this taxon is warranted for listing throughout all its range, and, therefore, finds that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

RECOMMENDED CONSERVATION MEASURES

Recommended conservation measures include: Continue monitoring of Delaware Bay migratory and South American wintering populations; increase the availability of the horseshoe crab egg forage base by protecting horseshoe crab populations; and protect and enhance foraging and roosting habitat on the Delaware Bay and other Atlantic coastal sites. Although there is uncertainty as to risks posed by human disturbance and competition from gulls, we recommend developing management solutions to decrease competition from gulls and reduce human disturbance at roosting and foraging sites. Identify all important breeding locations and develop conservation strategies to protect key sites. Develop a system for determining yearly population demographic status based on survey results, capture data, and resightings of banded individuals. Develop and implement conservation plans for protection of key non-breeding habitats within North, Central, and South America.

LISTING PRIORITY

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
	Non-imminent	Subspecies/population	3
		Monotypic genus	4
		Species	5
		Subspecies/population	6*
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:

Magnitude: Harvest of horseshoe crabs at the principal migration stopover site within the Delaware Bay have significantly diminished the availability of horseshoe crab eggs that are the food resource critical for the red knots to rebuild fat reserves needed to continue their migration to Arctic breeding areas. From 1997 to 2002 an increasing proportion of red knots leaving the Delaware Bay failed to reach the threshold departure masses that are considered crucial to adult survivorship and reproductive success. Based on these peak counts at principal wintering areas

and a Delaware Bay in 2004-2006, it appears the population declines may have ceased or slowed. However, the issue of depletion of forage resources in the Delaware Bay has not been resolved. Recent and on-going efforts to reduce commercial harvest of horseshoe crabs may result in increased availability of eggs for migrating red knots, but the effects of the reduction in horseshoe crab will not be immediate, as it could take another decade before numbers of spawning horseshoe crabs rebound to the point that red knots can make the necessary weight gain in all years, especially those crucial bad weather years. Habitat loss due to erosion and shoreline protection practices also pose risks. Based on consideration of all of the available information we consider the magnitude of the threat to be high at this time.

Imminence: The reduction of horseshoe crab food resources on the Delaware Bay has been ongoing since the mid-1990s, but quotas or harvesting bans have been recently implemented. We expect it will take a few years for the food resource to recover, due to the slow maturity of horseshoe crabs. Because we believe this threat is being appropriately managed at the present time, it is not considered to be imminent. If population levels of horseshoe crabs do not rise such that the red knot can forage sufficiently to obtain optimum body weight for migration and thus have adequate survival and reproductive success that is reflected in stable or increasing populations, then we must revisit this conclusion. Erosion of shoreline habitat is an on-going problem in the Delaware Bay, but this does not appear to be as significant a threat as the modification of habitat related to depletion of horseshoe crabs. Consequently, overall we conclude that threats are nonimminent at this time.

_____ Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed? Yes

Is Emergency Listing Warranted? No

Commercial horseshoe crab harvesting has been identified as a key factor in the decline of the red knot. Erosion of beach habitat and human disturbance also may be contributing to the decline. However, restrictions have been adopted on the harvest of horseshoe crabs in the Delaware Bay area, and protective measures have been undertaken by New Jersey and Delaware to limit human access along Delaware Bay beaches to prevent disturbance to red knots and other shorebirds foraging on horseshoe crab eggs. In 2004, following 5 years of reduced horseshoe crab harvest in the Delaware Bay, availability of horseshoe crab eggs on principal shorebird foraging beaches increased over recent years. Peak counts of red knots in the Delaware Bay have been similar for the past three years: 13,315 in 2004, 15,345 in 2005, and 13,445 in 2006. In May 2005, an aerial survey for red knots along Virginia's barrier islands recorded an estimated 9,150 knots (Watts and Truitt 2005) and a peak count of approximately 20,000 red knots was reported on the same survey date from ground counts of an Atlantic coastal site in New Jersey where most Delaware Bay red knots are believed to congregate at a nighttime roost. Thus, nearly 30,000 red knots were accounted for during the spring 2005 migration. Further, surveys by the Canadian Wildlife Service of the principal South American wintering areas indicate the wintering populations in 2007 did not show a significant decline from 2005. Overall, this information does not support emergency listing of the red knot.

DESCRIPTION OF MONITORING

Monitoring of the red knot will include review of current scientific literature and contacting species experts, and State and international resource agencies regarding red knot status and threats. These efforts will be on-going throughout the monitoring period and will occur as information becomes available.

COORDINATION WITH STATES

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment: The Service contracted the New Jersey Endangered and Nongame Species Program (NJENSP) to compile a status assessment for the red knot. A draft assessment provided to the Service underwent both internal and external peer review. The NJENSP is in the process of preparing an assessment final report. In the course of preparing the assessment, the NJENSP contacted biologists within each State along the Atlantic coast of the United States. All States contributed information.

Indicate which State(s) did not provide any information or comments: N/A

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APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:


Regional Director, Fish and Wildlife Service

Acting

4-30-07
Date

Concur:

Director, Fish and Wildlife Service

Date

Do not concur:

Director, Fish and Wildlife Service

Date

Director's Remarks:

Date of annual review: April 25, 2007

Conducted by: Annette Scherer, New Jersey Field Office

(Revised 04/25/07)